

Producing methane and oxygen on Mars using proton-conducting ceramics

Completed Technology Project (2017 - 2019)



Project Introduction

NASA Technology Area 7 identifies one of the challenges of exploration and human activities in space is the scarcity of readily usable resources. This scarcity is mainly due to limited payloads carried from Earth and lack of developed technology capable of optimally processing extraterrestrial resources in-situ. Therefore, payloads, activities, and the duration of a mission in space are very restrained. Current in-situ resource utilization (ISRU) methods are making headway to tackle this challenge. Conventional reactors are large in size, heavy, and have low performance in heat and mass transfer performance, which result in high costs while operating at very low rate and efficiency. Microchannel reactors overcome these limitations with their exceptional thermal regulation and chemical processes control, as well as scalability for higher production. They have high heat and mass transfer rates, which enables higher efficiencies, while their small scale design reduces size and weight, it also improves conversion, yield, selectivity, and catalyst life. Optimizing their design will allow for sustainable human activities in space. Besides significant improvements over conventional reactors, ceramic microchannel reactors are much more advantageous than metallic counterparts because of their lower cost and weight, higher resistance to corrosion, compatibility with ceramic-supported catalysts, and very high temperature operation. Ceramic microchannel reactors offer very high potential as an innovative, enabling technology for NASA TABS 7.1 "In-Situ Resource Utilization" goals as well as general space exploration missions. This project proposes to investigate the ceramic microchannel reactor technology as a potential innovation in performing ISRU. To demonstrate the space ISRU capabilities of a ceramic microchannel reactor, the project aims to build upon the goal of human exploration on Mars. Since Martian atmosphere is composed of mainly carbon dioxide, and water is present as a hydrogen source, the Sabatier chemical reaction will be used to convert carbon dioxide and hydrogen to water and methane, which is to be used as propellant. The specific objective is to achieve a production rate of more than 32 grams per hour of methane and at least 72 grams per hour of water, as goals defined by NASA's Mars Atmosphere and Regolith Collector/Processor for Lander Operations project. The project will occur within the scope of a two-year MS thesis program, consisting of two phases. In phase one, all testing with Sabatier process in the current ceramic microchannel reactor will be completed. Experimentation will be performed on the existing full test stand with a ceramic microchannel reactor at the Colorado Fuel Cell Center, Colorado School of Mines. ANSYS Fluent models will be made to develop understanding of internal Sabatier kinetics within the reactor and to interpret reactor physical processes. Phase two will focus on the optimization of the reactor to enhance performance and reconfigure infrastructure for Mars ISRU application. Through which, ruthenium catalyst will be applied into experimentation and new system-designs will be developed to integrate hydrogen-separation membranes. Throughout the project, results will be presented at conference proceedings, and finally ending with dissemination of findings in peer-reviewed



Producing methane and oxygen on Mars using proton-conducting ceramics

Table of Contents

Project Introduction	1
Anticipated Benefits	2
Primary U.S. Work Locations and Key Partners	2
Organizational Responsibility	2
Project Management	2
Project Website:	3
Technology Maturity (TRL)	3
Technology Areas	3
Target Destination	3

Producing methane and oxygen on Mars using proton-conducting ceramics

Completed Technology Project (2017 - 2019)

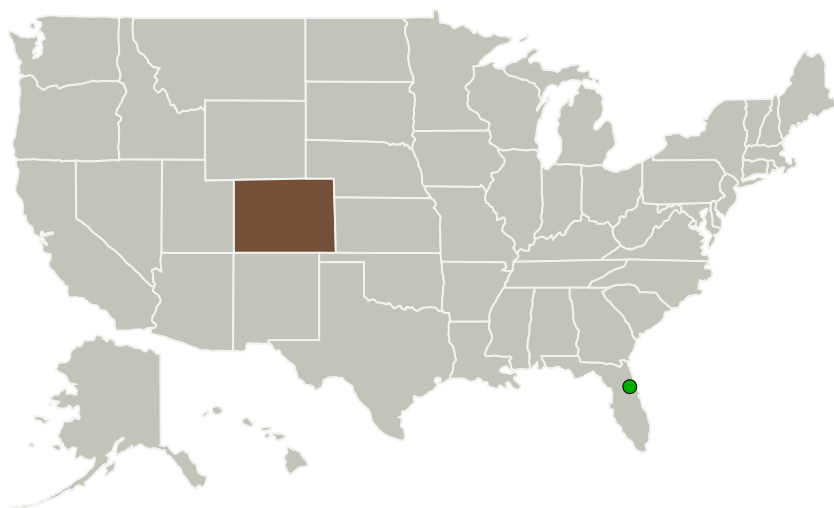



literature.

Anticipated Benefits

Ceramic microchannel reactors offer very high potential as an innovative, enabling technology for NASA TABS 7.1 "In-Situ Resource Utilization" goals as well as general space exploration missions. This project proposes to investigate the ceramic microchannel reactor technology as a potential innovation in performing ISRU.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Colorado School of Mines	Lead Organization	Academia	Golden, Colorado
 Kennedy Space Center(KSC)	Supporting Organization	NASA Center	Kennedy Space Center, Florida

Primary U.S. Work Locations

Colorado

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Colorado School of Mines

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Neal Sullivan

Co-Investigator:

Duc N Nguyen

Producing methane and oxygen on Mars using proton-conducting ceramics

Completed Technology Project (2017 - 2019)

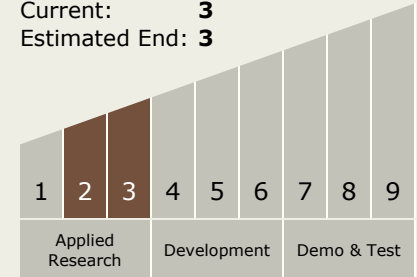


Project Website:

<https://www.nasa.gov/strg#.VQb6T0jJzyE>

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
 - └ TX07.2 Mission Infrastructure, Sustainability, and Supportability
 - └ TX07.2.1 Logistics Management

Target Destination

Mars